

to the compiler likely to be of particular interest in connection with the work of the Weather Bureau:

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WEATHER BUREAU EXHIBIT AT THE PAN-AMERICAN EXPOSITION, BUFFALO, N. Y.

By D. T. MARINE, in charge of Installation.

The Weather Bureau exhibit at the Pan-American Exposition is located in the northeast corner of the North Pavilion, Government Building, and is adjacent to and forms a part of the official exhibit of the United States Department of Agriculture. The exhibit is shown quite completely in the accompanying illustrations—Plates I, II, and III—but can best be described under four general groups, or sections, as follows:

1. A collection of meteorological instruments and apparatus of latest improved designs, some in actual operation as employed at the more important telegraphic reporting stations of the Weather Bureau; kites and kite outfits as used in aerial investigations.
2. A collection of storm-warning flags and lanterns, with supports and towers, as used on the lakes and seacoasts for giving warnings of the approach of storms dangerous to shipping; model tower and weather flags.
3. A complete set of framed charts and publications of the Bureau, presenting clearly and graphically the climatic conditions of the United States; miscellaneous photographs of clouds, lightning, etc.
4. A map-printing and forecast section in daily operation.

1. METEOROLOGICAL INSTRUMENTS AND APPARATUS.

The general arrangement of this section of the exhibit is shown on Plate I, a view taken from one of the main aisles of the building, but does not include several instruments and apparatus on both the right and left hand.

For measuring atmospheric pressure the following are displayed:

Normal mercurial barograph, designed by Prof. C. F. Marvin. Records automatically and continuously the varying pressure of the air by means of a mercurial barometer tube suspended on a balanced scale beam. Aneroid barographs of the Richard pattern, such as are in actual use at 150 stations of the Weather Bureau. Nonrecording mercurial barometers of the standard pattern, in cases of special design, together with two sample barometers having sections cut out of the cisterns to show details of construction. For the especial benefit of the lake maritime interests there are also displayed samples of the best grades of compensated aneroid barometers, such as the patented Watkin, and others of English and French manufacture. These samples are loaned for exhibit by Mr. Julien P. Friez, of the Belfort Observatory, Baltimore, Md.

Air temperature apparatus.—Under the head of instruments for indicating and recording the temperature of the air we have: (a) The telethermograph, or transmitting thermometer, manufactured by Richard, Paris, in two forms; one is in actual operation with transmitter located in the instrument shelter on the roof and the register in the exhibit, and the other is shown complete in the exhibit. These instruments produce continuous and automatic records of the temperature of the air at a distance, and are especially desirable where the outdoor instrument shelter must be located some distance from the observer's office. (b) Thermographs of the regular pattern, such as are in actual operation at 150 stations of the Weather Bureau, and which produce a continuous and automatic record of the temperature wherever placed. (c) A col-

lection of sample thermometers of the several kinds regularly employed in meteorological work, viz: the mercurial exposed, for obtaining the current air temperature, dew-point, and humidity; the mercurial maximum, for recording the highest, and the alcohol minimum, for recording the lowest, air temperature. An instrument shelter of the standard (small) size is in position and use on top of the building (see Plate III), which is conveniently accessible for visitors by broad stairway.

Humidity: Psychrometers.—The question of relative humidity, or percentage of moisture in the air, is one that is closely connected with that of temperature. The standard instrument used by the Bureau for determining this element, consists of a geared apparatus, by means of which wet and dry bulb thermometers mounted thereon may be rapidly whirled and ventilated to insure accurate readings. A sample of this apparatus, together with one of more portable form known as the sling, or hand, psychrometer, is also shown. Samples of the hair hygrometer, of the so-called polymeter pattern devised by Lambrecht, of Germany, are also on exhibit (from the Belfort Observatory, Baltimore, Md.), to indicate some of the various forms of instruments that may be employed to determine humidity.

Precipitation: Rain and snow gages.—Of instruments for measuring precipitation (rain and snow fall) are shown: (a) The automatic weighing rain and snow gage, designed by Prof. C. F. Marvin, of the Weather Bureau. Two complete instruments are on exhibit; one is connected up on short circuit, and the actual operation of the mechanism is shown by dropping water artificially into the receiver, while the other has the gage part located on the roof of the building to receive and record on the register below all precipitation, in thousandths of inches, that may fall in that place. (b) Two of the improved tipping-bucket rain gages are similarly exhibited, that is, one is on short circuit, recording each hundredth of precipitation from water artificially dropped into the receiver, and the other is placed on the roof to catch and record actual rainfall. Over 100 stations of the Weather Bureau are now equipped with this pattern of recording rain gage. (c) The standard 8-inch (nonrecording) rain and snow gage. This is the well-known pattern in use at over 3,100 stations in the United States.

Wind velocity and direction apparatus.—For measuring and recording the direction and velocity of the wind, samples of the standard types of apparatus are installed. To obtain accurate directions and velocities of the wind it is essential that the wind vane and anemometer be given perfectly free exposures. To this end, one of the regular pattern 40-foot steel towers, as adopted for use at certain display stations, was erected on the roof of the building and the wind vane and anemometer were given elevations of 45 and 47 feet, respectively above the roof platform, and about 100 feet above the ground (see Plate III). The wind instruments thus exposed are connected electrically with a meteorograph in the exhibit, on the record sheet of which are automatically produced ink tracings and marks that record the direction of the wind for each minute of the day to eight points of the compass and the movement of the wind in miles.

Sunshine and cloudiness.—The important elements of sunshine and cloudiness, in daytime, are recorded by the Weather Bureau by two different forms of apparatus, models of each of which are shown. (a) The thermometric sunshine recorder, a form of differential thermometer, with clear and blackened bulbs, makes a record of sunshine electrically, each minute, by means of suitable wire connections with the meteorograph mentioned above. Two of these thermometric sunshine recorders are installed, one in the exhibit and the other in actual use on top of the 40-foot tower on the roof (Plate III). (b) The photographic sunshine recorder. This is a modified form of the Jordan photographic sunshine re-

corde, and gives the time and duration of each day's sunshine and cloudiness as traced by a minute beam of the actual sunshine on the sensitized (blue print) paper inclosed within the instrument. Interesting actual records are shown in an adjacent frame, and illustrate, graphically, the differences in the lengths of the days on similar dates in the southern and northern parts of the United States.

Station meteorographs.—The meteorograph, or triple register, mentioned above is now installed and in continuous operation at over 100 stations of the Weather Bureau throughout this country and the West Indies. As already referred to, this register, when properly connected with its various accessories, produces automatically the following records:

(a) The direction of the wind, to eight points of the compass, for each minute of the day (twenty-four hours).

(b) Each mile of wind movement, with the time in which made, from which the velocity is easily deduced.

(c) Each hundredth of an inch of rainfall (from the tipping-bucket rain gage) and the time required to collect this amount.

(d) The duration of sunshine and cloudiness during the time the sun is above the horizon (from the thermometric sunshine recorder).

A model wind vane in the exhibit, together with an anemometer with revolving cups, a thermometric sunshine recorder, and the bucket and frame of a tipping-bucket rain gage, are connected electrically with a meteorograph to illustrate graphically the methods employed in securing automatically the meteorological data above mentioned. Smaller forms of registers are also exhibited for obtaining records of wind velocity alone; wind velocity and sunshine; wind velocity and rainfall, or all three elements on the same record sheet.

Cloud observing apparatus.—In 1896-97 simultaneous, international cloud observations were made throughout the world by mutual agreement of the various national meteorological services. One of the cloud theodolites used in making these observations at Washington, D. C., is shown. By the aid of apparatus of this kind, two observers stationed about a mile apart and connected by telephone could locate with great accuracy the same point on any cloud under observation. An adjacent picture shows how the apparatus was actually used by each observer. The observations obtained were used in determining the actual height and velocity of clouds, and the results are given in the Annual Report of the Chief of Bureau for 1899. Near this apparatus is also shown one of the cloud nephoscopes and supports devised by Professor Marvin, and used at various stations of the Bureau in making cloud observations. By aid of a graduated plane mirror and its attachments, the azimuth, the angular altitude, the direction of motion and apparent velocity of motion of clouds are readily ascertained.

Kites and aerial investigations.—In kite apparatus there is shown a complete outfit as used in the field at one of the special kite stations. On the floor of the exhibit is a full size, standard, Weather Bureau kite of improved design, with a complete set of instruments attached thereto as in actual use, while near the ceiling of the building, in an opposite diagonal corner, hangs another kite of slightly smaller size, poised as in flight and connected by steel wire with a standard pattern hand reel which was actually used in making aerial investigations. The reel controls the kite in flight, and may be swung around to keep with the kite at any point of the compass. It is fitted with dials for indicating the length of wire out; a graduated rod and radius arc for showing the inclination of the wire to the horizontal plane, and has a dynamometer fastened to one of the crank handles for indicating, in pounds, the tension on the line. This reel, as well as the kite meteorographs and apparatus shown, were designed

by Professor Marvin, and some of the actual automatic records obtained with one kite from elevations exceeding 7,000 feet, are displayed near the larger kite. Observations on the angular elevation and azimuth of the kite, when in flight, were made by means of a circular horizontal mirror mounted on leveling screws. A sample of this instrument is also shown and is similar to the cloud nephoscope mentioned above.

2. STORM-WARNING AND WEATHER FLAGS, LANTERNS, ETC.

Owing to the great commercial importance of the City of Buffalo and the immense lake shipping interests centered at that point, special attention was given to this section of the exhibit, and the following were installed:

(a) *Storm-warning and weather flags.*—Draped on the walls at the back of the exhibit are full size hurricane flags, pennants, etc., while on the sides of one of the supporting pillars of the roof are a collection of small models of these flags (one-tenth actual size), showing the combinations possible, from the hurricane warning to the warning indicating the storm quadrants. Models of the regular weather and temperature and cold wave flags (one-tenth size) are similarly displayed on an opposite side of the pillar.

(b) *Storm-warning lanterns and supports.*—Four pairs of lanterns are displayed, viz: One pair (2) standard electric lanterns, with 12-inch Fresnel lenses (one red and one white), mounted rigidly upon a sample special 20-foot iron mast support, provided with iron steps; one pair (2) of the improved oil-burning lanterns, both with white 12-inch Fresnel lenses, but with the burner of one fitted with a red chimney, displayed as in actual use in one hoist, with ropes and tackle as attached to a wooden flagstaff, for example; one pair (2) of the marine 8-inch Fresnel lens lanterns (one red and one white), shown in one hoist as from a flagpole; one pair (2) of 4-inch Fresnel lens lanterns (models¹), one red and one white, mounted as in actual use on the model tower. This tower is an exact fac simile in miniature (one-fifth actual size) of the standard 75-foot towers erected at display stations. All parts are clearly shown, in reduced scale, from the special drum and hoisting attachment for the lanterns to the miniature wind vane and arrangement of halyards for flags at the top, and the whole is nicely finished, nickel plated, and polished. This model was manufactured with great care by the contractors for the large towers, The Flint and Walling Manufacturing Company, Kendallville, Ind., and is neatly mounted on a polished oak pedestal. It forms an attractive corner of the exhibit, on the main aisle, and the lower portion may be seen conspicuously in center and front, Plate I. The model weather and temperature flags, as well as those for storm warnings, are displayed for the daily forecasts from the flagstaff of this model tower.

The full size 40-foot steel tower (combined wind instrument support), Plate III, is also especially adapted for the display of storm warnings by means of high-power lights, and is so used at various important stations of the Bureau.

Neatly designed pocket cards, in colors, explaining the various flags and warnings of the Bureau are freely distributed to all interested visitors.

3. FRAMED CHARTS, ETC., AND BUREAU PUBLICATIONS.

(a) *Charts and photographs.*—This section embraces a collection of 91 framed charts, etc., showing various meteorological phenomena. These are maps illustrating the climatic conditions of the United States, compiled and prepared from observations extending back to the establishment of the ser-

¹ These miniature lanterns are finished complete with oil burners, etc., and were constructed especially for this exhibit by Mr. Peter Gray, of Boston, Mass., the contractor for the standard patterns, all of which are of American manufacture throughout.

vice in 1870; photographs of typical forms of clouds and of lightning and its effects, and miscellaneous photographs. These are mounted in classified groups on the walls of the exhibit (Plates I and II) and the data shown is supplemented by two composition relief maps of the United States in colors, giving the contour of land surfaces, and, in appropriate harmonious tints and lines thereon, the mean annual rainfall and temperature.

The collection is as follows:

Five framed climatic charts, showing rainfall, seasonal and annual.

Nine framed climatic charts, showing temperature data, from the mean annual to the highest, lowest, etc.

Three framed climatic charts, showing average barometric pressure for January and for July, and the mean annual.

Three framed climatic charts, showing average sunshine for January and for July, and mean annual.

Six framed sample Washington weather maps, showing the movement of a typical storm.

Five framed charts of actual automatic records obtained from standard Weather Bureau instruments.

One framed map, showing, geographically, the telegraphic circuits of the United States and the West Indies.

Six framed photographs of lightning and its destructive effects on trees, etc.

Twenty-one framed photographs of clouds; typical forms of various kinds.

One framed photograph (transparency), cumulo-nimbus clouds.

Eighteen framed photographs of various forms of kites and some of the experimental apparatus in the aerial investigations.

Six framed lake marine charts, showing water currents and fog conditions on the Great Lakes.

Seven framed photographs of miscellaneous subjects; Lake steamers; Weather Bureau buildings; Central Office of the Weather Bureau at Washington, etc.

One relief map (small), showing mean annual rainfall and temperature. (As furnished for special use at climate and crop section centers.)

One relief map (large), showing mean annual rainfall and temperature on a greatly enlarged scale.

(b) *Publications.*—Samples of the regular publications of the Bureau and such pamphlets as have been found of most interest to the general public are displayed, together with a set of station text and reference books, relating especially to meteorology and agriculture.

In this connection a blank book is provided wherein are noted the names and addresses of visitors who are particularly interested in meteorological matters, and requests for such publications as they may desire. The publications are forwarded gratuitously from the Central Office at Washington, if available.

To add to the completeness of this section and the exhibit generally, we are favored with a large lifelike portrait of the Hon. James Wilson, Secretary of Agriculture. There is also a framed photograph of Prof. Willis L. Moore, Chief of Bureau; and among the decorative effects on the burlap covered walls may be noticed a large plaster cast four feet in diameter, which is a reproduction in colors of the great seal of the United States Department of Agriculture. Every chart, instrument, and article of exhibit has a card with name and suitable descriptive legend thereon.

4. MAP PRINTING AND FORECAST SECTION. (Plate II.)

(a) *Weather map.*—In harmony with the enterprising spirit which prompted and has carried to completion this beautiful All-American Exposition, action was taken to perfect a new weather map that would embrace, with the United States, as

many as possible of the American republics to the south, and, of course, the contiguous territory of Canada and British America on the north. The size of the map was limited to 19 by 24 inches, and the territory actually included is from 10° to 55° north latitude (about 3,000 miles), and from 45° to 130° west longitude (about 4,200 miles), or over 12,000,000 square miles, the largest section of the earth's surface ever covered by a single synoptic weather chart made up from telegraphic observations. This map was engraved with the utmost care and printed in two harmonious tints of brown and green. Copies of the blank chart can be furnished to students of meteorology.

(b) *Weather forecasts and map printing.*—For the preparation of this map daily telegraphic reports are required from over 165 stations. These reports, passing over the regular telegraphic circuits, are received, translated, and tabulated at the down-town Weather Bureau office in Buffalo, and, as soon as the regular issue of maps has been printed, proofs, etc., are sent to the Weather Bureau Exhibit at the Exposition Grounds, four miles distant. Here the lines and data are rapidly transferred to stone for the printing of the souvenir edition on the large map described above. The exhibit is equipped with a telephone in connection with the city office, and while the small city maps are being prepared and printed, all data that can be transmitted in this manner, including the daily forecasts, etc., are rapidly passing over the line to the official in charge of the exhibit so that everything is ready for the transfer of the lines and tabular data when these are received. In this way the telegraphic observations taken at the 165 stations scattered over this vast extent of territory at 8 a. m., seventy-fifth meridian time, are being printed in colors (black and red) on the completed Pan-American Exposition weather map by 12 noon of the same date.

(c) *Printing press and accessories.*—For the printing of the above-described souvenir map the Weather Bureau is especially indebted to Messrs. Walter Scott & Co., Plainfield, N. J., who kindly loaned for the purpose the very handsome and complete two-color lithographic press, shown in Plate II. This is operated by a special 5-horsepower electric motor, constructed and loaned by The General Electric Company, of Schenectady, N. Y. Proof presses and all the necessary ap-

pliances for lithographic work are installed in this section, and the complete and special processes employed by the Bureau in preparing and transferring meteorological data to stone, and in the printing of weather maps therefrom, are conducted in full view of all interested visitors.

(d) *Folding machine.*—The large size of the map makes it essential that it be quickly and neatly folded for mailing or distribution, and a folding machine was arranged especially for this purpose and courteously loaned to the Bureau by the Dexter Folder Company of New York. This ingenious and useful machine is clearly shown near hand railing in front of press in the illustration, Plate II.

Souvenir envelopes printed in colors, showing the national ensigns of some of the more important American republics, together with cuts of storm and weather flags in daily use by the Bureau, were prepared for holding and facilitating the distribution of the maps. The maps are also posted daily in suitable frames conspicuously located in the more important buildings and thoroughfares on the Exposition Grounds.

(e) *Telephones: city and local.*—To facilitate the prompt receipt of weather reports, data for the maps, the daily forecasts, etc., and for the distribution of special warnings, the exhibit is fully equipped with both city and local telephones. By means of the latter and an exchange located on the grounds, all the more important buildings and exhibits of the Exposition can be promptly reached.

The exhibit is in charge of Mr. David Cuthbertson and a corps of assistants who have had many years' training and experience in the meteorological work of the Bureau, and they take pleasure in explaining the instruments, apparatus, etc., to all interested visitors. An effort has been made to make this very complete working exhibit of especial interest to the hundreds of voluntary observers of the Weather Bureau who will probably visit the exposition, and it is hoped that it may have a passing interest, at least, to all others who may see it.¹

¹The illustrations accompanying this article were obtained through the courtesy of Mr. Harry H. Brigham, Assistant Representative in charge of the Exhibit of the United States Department of Agriculture, and Mr. David Cuthbertson, Forecast Official in charge Weather Bureau Exhibit. This favor, the many timely suggestions, and the cordial assistance rendered me by these gentlemen in the arduous work of installing our exhibit are gratefully appreciated.—D. T. M.

NOTES BY THE EDITOR.

HAIL AND THUNDERSTORMS IN OREGON.

Notable thunderstorms and hail occurred at Springfield, Lane Co., Oreg., 44° 5' north; 123° west, and at Aurora, Palmer County, 45° 16' north; 122° 50' west. Springfield is in the valley of the upper Willamette, and Aurora is not far from the Willamette in the lower portion of its course. The following items are taken from special reports addressed by Climate and Crop correspondents to Mr. E. A. Beals, Forecast Official and Section Director at Portland, Oreg.

At Springfield Mr. J. S. Churchill says:

Saturday, May 25, 1901, was quite warm and sultry. At 2 p. m. a black cloud formed in the southeast and moved slowly in a northwest direction. Shortly afterward a similar cloud formed in the southwest and moved in a northeasterly direction. About 4 p. m. these two clouds were merged into one, moving violently over the country in a westerly direction accompanied by thunder, lightning, and hail. Hailstones, many of which were 1½ inches in diameter, fell thick and fast for a period of ten minutes, along with a deluge of water. The main storm of hail began at a point about seven miles east of the town of Springfield, and covered a space of from three to five miles wide and from seven to ten miles long. Near the center of the end of this path the wind developed to hurricane force, uprooting and breaking off trees three feet in diameter. Such a hailstorm has never been experienced before by the writer during his fifty years residence in Oregon.

Mr. J. C. Brattain, also of Springfield, says:

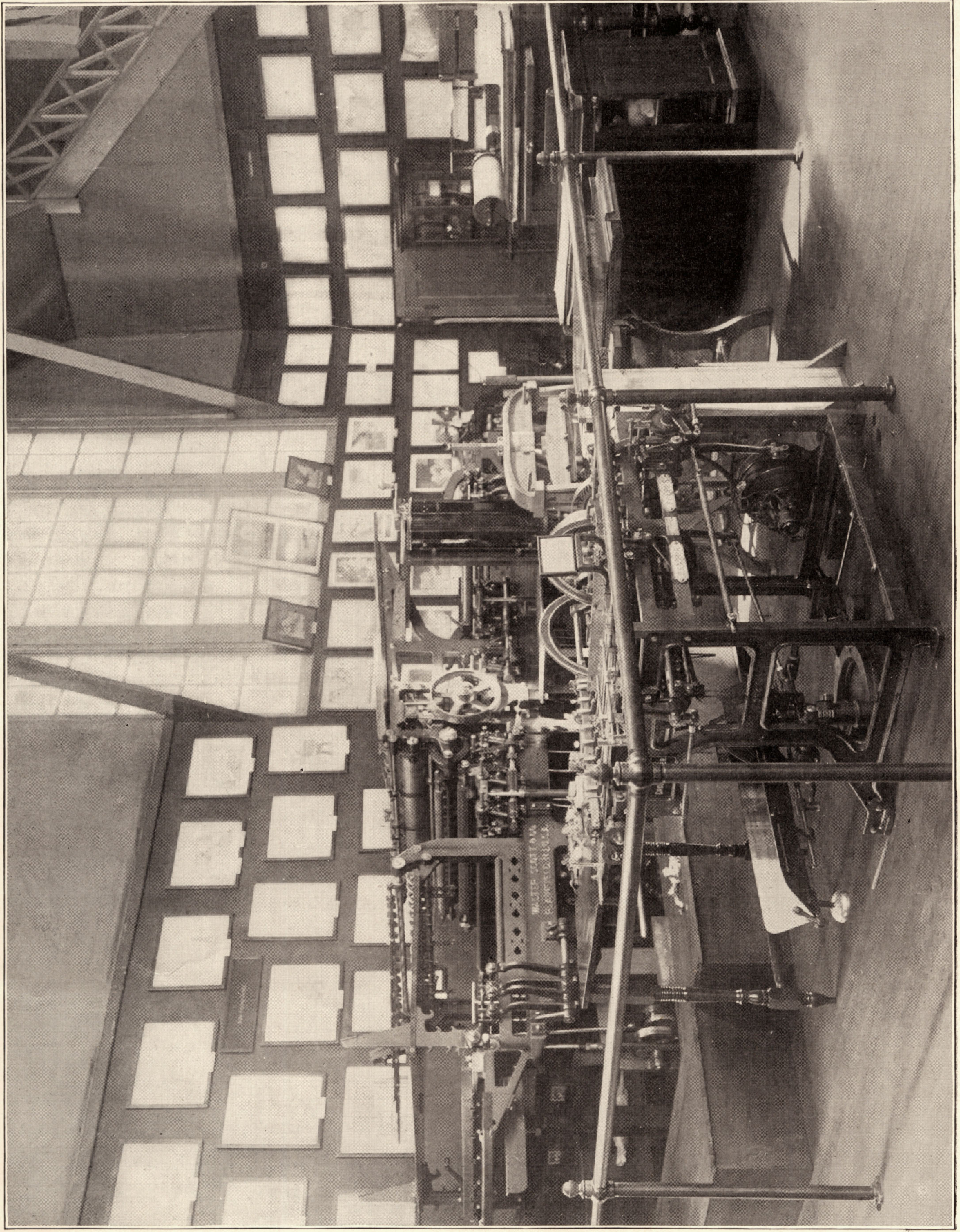
The hail extended over about six or seven miles in length and four in width. The stones were from three-quarters to one inch in diameter, but occasionally 2 inches; there were narrow strips in the storm's course from southeast to northwest where it was especially severe.

Mr. Charles J. Dodd, of Springfield, states that he rode over and examined a large portion of the area affected by the hail, and finds that the afternoon was quite warm, viz, temperature about 70° F., with a gentle breeze from west-northwest. Three distinct thunderheads made their appearance about 3 p. m. One formed in the coast range west of Cottage Grove, and drifted northeastward, another formed near Diamonds Peak in the Cascade range, and drifting rapidly northwest, followed the Willamette River. The third began west of the Three Sisters and drifted almost due west. At 3:30 p. m. these three clouds met about half a mile south and west of the town of Springfield. Here the destruction was greatest, and the width of the storm at this point was about two miles. It became suddenly very cool, the temperature fell to 45° F., the wind changed to southwest and the cloud swept toward the north or northeast. The total length of path was about sixteen miles with an average width of two miles. The damage done by the hail was between \$10,000 and \$20,000, while the size of the hailstones varied from one-fifth to two and one-half inches in diameter; in many cases two or three of these were frozen together; near the center of the track the average size might be compared to large sized English walnuts.

With regard to the storm at Aurora, Mr. G. Muecke reports as follows:



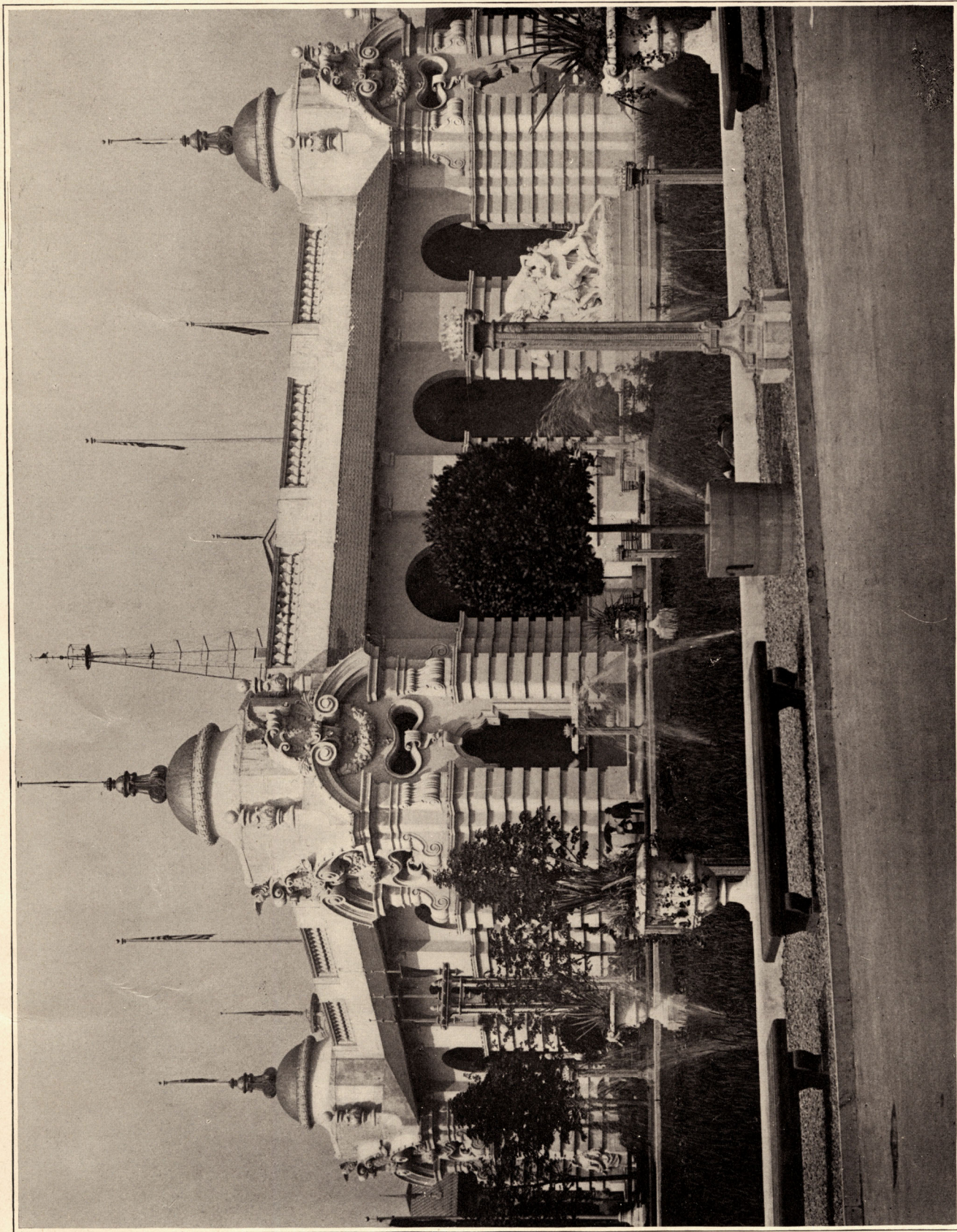
Meteorological instruments and apparatus.



Weather forecast and map-printing section.



Roof of North Pavilion, Government Building; wind instruments on 40-foot steel tower.



North Pavilion, Government Building, containing exhibits of the United States Department of Agriculture.